

APPENDIX

Meetings

Summits

NIA Compliance

**FHWA: Off-Model Air Quality Analysis – A
Compendium of Practice – August 1999**

ITS Strategic Deployment Plan

Asheville Regional Summit
March 8, 2000, 8:00 AM
MEETING SUMMARY

Attending:

| <u>Name</u> | <u>Agency</u> | <u>Phone</u> |
|-----------------------|---|--------------|
| Gene Adair | Transit Department- Director | 828-287-6153 |
| Ann Almond | Rutherford County Tourism Development Authority | 828-245-1492 |
| Karen E. Andrews | Rutherfordton- Manager | 828-287-3520 |
| Tom Blanton | Rutherfordton- Fire Chief | 828-287-7367 |
| George Briggs | NC Arboretum- Director | 828-665-2492 |
| Frank Burns | Kings Mountain- Fire Chief | 704-734-0555 |
| Charlie Carden | NCDMV-Asst. Director, Enforcement Section | 919-861-3164 |
| Christopher A. Carter | Hendersonville- Manager | 828-697-3000 |
| Larry Cochran | Polk County- Chief Deputy | 828-894-3001 |
| Russell Cochran | Town of Black Mountain- Planner | 828-669-0079 |
| Debbie Collins | NCSU, ITRE, Transit Operations-Manager | 704-639-7653 |
| Scott Cook | NCDOT Div. 13-Asst. Division Traffic Engineer | 828-251-6171 |
| Tom Cowan | Mission St. Joseph's Hospital | 828-213-0910 |
| Michael Crater | Polk County- Emergency Preparedness | 828-894-3067 |
| J. Earl Daniels | City of Marion- City Manager | 828-652-3557 |
| Larry M. Dehart | NCDOT Division 14- Division Operations Engineer | 828-586-2141 |
| Mark Dunzo | Kimley-Horn and Associates | 919-677-2000 |
| R. Thomas Edmundson | Henderson County- Director-EMS | 828-697-4825 |
| George H. Erwin | Henderson County- Sheriff | 828-698-6102 |
| Gary Everhardt | Blue Ridge Parkway- Superintendent | 828-271-4718 |
| Ginny Faust | NC Division of Community Assistance | 828-251-6194 |
| Tere Finch | Western NC Sierra Club-Chairman | 828-251-1983 |
| Kenn Fink | Kimley-Horn and Associates | 919-677-2000 |
| Ron Fuller | Asheville MPO-Transportation Planner | 828-259-5842 |
| Oliver Gajda | Asheville MPO- Pedestrian And Bike Coordinator | 828-232-4528 |
| D. (Bucky) Galloway | NCDOT (Area 5)-Area Traffic Engineer | 828-251-6178 |
| Randy Greenway | Rutherfordton- Chief of Police | 828-287-5062 |
| James B. Hambricht | NCDOT-Traffic Congestion & Engineering Operations | 919-250-4151 |
| Shannon Harding | Yancey County Chamber of Commerce | 828-682-7413 |
| Stephanie Harris | Kimley-Horn and Associates | 919-677-2000 |
| Elizabeth Honeycutt | NCDOT-Traffic Congestion & Engineering Operations | 919-250-4151 |
| Terry M. Hopkins | NCDOT-Traffic Congestion & Engineering Operations | 919-250-4151 |
| Carla Horton | Mission St. Joseph's Hospital | 828-213-0910 |
| M. James | NCSHP-Troop "G" Headquarter | 828-299-4626 |
| Henry T. Johnson | Laurel Park- Mayor | 828-693-4840 |
| Harold Laflin | Buncombe County Schools | 828-232-4240 |
| Michele Lawhern | Yancey County Manager | 828-682-3971 |
| Ann R. Lorscheider | NCDOT-Traffic Congestion & Engineering Operations | 919-250-4151 |
| Steve Meyer | David Volkert & Associates | 423-842-3335 |
| Rochelle Miller | Apple Country Transportation | 828-693-1711 |
| David Miller | NCSHP- Lieutenant | 828-298-4253 |

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| | | |
|-------------------|--|-----------------------|
| Larry Modlin | Warren Wilson College- VP for Business | 828-298-3325 ext. 223 |
| Reuben Moore | NCDOT Division 14- Division Traffic Engineer | 828-586-2141 |
| Michael J. Morgan | Weaverville- Manager, TCC Chairman | 828-645-7116 |
| Ronald J. Morgan | Lake Lure- Fire Chief | 828-625-9333 |
| Michael Moule | Asheville- Traffic Engineer | 828-259-5943 |
| William Moyer | Henderson- Commissioner | 828-697-4808 |
| Sam Nichols | NCDOT-Division Traffic Engineer | 704-480-5400 |
| Fred H. Niehoff | Hendersonville- Mayor | 828-697-3000 |
| Jo Ann Oerter | NCDOT-Traffic Congestion & Engineering Operations | 919-250-4151 |
| C. Yates Pharr | Biltmore Farms, Inc.- Vice President | 828-274-2000 ext. 108 |
| Chuck Pickering | Biltmore Estate-Executive Vice President | 828-255-1745 |
| Michael Plemmons | Asheville Council of Independent Business Owners | 828-254-2426 |
| Kenneth Putnam | NCDOT Division 13- Division Traffic Engineer | 828-251-6171 |
| Rodney Raines | Henderson County- Captain | 828-698-6102 |
| G. P. Ramsey | N.C. Division of Motor Vehicles -Enforcement | 704-251-6081 |
| Wil Ravenhorst | Kimley-Horn and Associates | 919-677-2000 |
| Jim Rhine | City of Asheville- Traffic Operations Manager | 828-259-5456 |
| Michael Rouse | McDowell County Tourism | 828-652-1103 |
| Ron Ruehl | N.C. Dept. of Commerce, Division of Tourism | 828-277-7096 |
| Jerry Ruppe | NCDOT Division 12-Division Operations Engineer | 704-480-5400 |
| Len Sanderson | NCDOT-State Highway Administrator | 919-733-7384 |
| Ray Shaw | Flat Rock- Council Member | 828-697-8100 |
| Wilma M. Sherrill | North Carolina, District 51- NC House Representative | 919-715-4466 |
| Doug Sims | Weaverville-Fire Chief | 828-645-3300 |
| William D. Smart | NCDOT Division 13- Division Engineer | 828-251-6171 |
| Richard Sullins | Maryland Community College | 828-765-7351 ext.248 |
| Mac Swicegood | Council of Independent Business Owners -President | 828-252-5393 |
| Max Tate | FHWA- Research and Technology Engineer | 919-856-4354 |

The ITS Strategic Deployment Plan– Asheville Regional Summit commenced at approximately 8:00 AM at the North Carolina Arboretum in Asheville, North Carolina. Following is a summary of the proceedings of this meeting.

8:00-9:00 AM Guests were registered and given the opportunity to explore demonstrations that were given on ITS technologies. Included was a demonstration of NCDOT's ncsmartlink.org traffic information web page; a presentation of web pages across the nation showing real-time traffic information, and a video demonstrating ITS applications. Coffee and doughnuts were available during this time.

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- 9:00-9:15 Mr. Len Sanderson, P.E., State Highway Administrator for the North Carolina Department of Transportation, welcomed the guests and shared his vision of ITS in the region.
- 9:15-10:00 Kenn Fink, P.E., Mark Dunzo, P.E., and Stephanie Harris, P.E., presented an overview of ITS that included specific technologies as well as their benefits.
- 10:00- 10:15 Break
- 10:15-11:00 Mr. Reuben Moore, P.E., Division 14 Traffic Engineer for the North Carolina Department of Transportation and Mr. Ken Putnam, P.E., Division 13 Traffic Engineer for the North Carolina Department of Transportation spoke about the existing ITS deployments in the area and how those systems were currently being used. An example of how ITS was used during the I-40 rock slide was also discussed. Mr. Ron Ruehl, Heritage Tourism Development officer for NC Travel and Tourism, discussed the present and future condition of tourism in the area.
- 11:00-12:00 Breakout sessions were conducted with four groups, each one focusing on a specific topic. Groups were asked to answer/discuss a series of questions on the topics of Traffic/Incident Management, ITS for Transit, Traveler Information Systems, and Commercial Vehicle Operations. Summaries from the breakout groups are shown below.

BREAK-OUT GROUP FINDINGS

TRAFFIC MANAGEMENT and INCIDENT MANAGEMENT

Problems:

- I-240 (Asheville)- Smokey Park Bridge
- I-26 East - Saluda grade
- Four Seasons Blvd. (Hendersonville)
- Tourist Peaks (in both directions) on Thursday and Friday afternoons
 - Geographic lack of alternate routes, choke points
 - No capacity for extra traffic of tourism
 - Local commuter traffic exceeds capacity
- I-26 (Saluda) - no coordination with South Carolina and minimal interagency on most levels (during chemical spill Dec. 98')
- I-40- Rockslide - took the DOT Secretaries and Governor's in order for there to be communication between NC and Tennessee

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- There was a re-routing during bridge reconstruction with South Carolina, better coordination needed
- It is good to have large encompassing detour regions
 - Get information out early enough for travelers to have options for alternate routes
 - Guardrail on all divided highway in the state with in next few years
 - ♦ Breaks every 3 miles plus interchanges
 - A unified system- (example: Henderson vs. Buncombe, GIS is not compatible)
 - Database in GIS of signal location
 - ♦ Improve pedestrian crossing
 - ♦ Improve signal timing
- Columbus- Lack of exits from US 74 west onto I-26 east- creates congestion
- Road closure system/network
 - Weather detection (fog, snow) affect on traffic
 - Better planning of truck ramps
 - Watershed for town of Weaverville/public water supply
 - ♦ Chemical spill, diesel, etc.

Solutions:

- Jurisdiction - Asheville Police Department coordinate better
- Getting information out on traffic conditions (especially with opening of I-26)
- Incorporate ALL of west North Carolina - once a traveler comes in, difficult to easily leave
- Signage - Interstate communication
- Local Emergency/Incident Management coordinator
 - No IMAP unit
 - Need IMAP coordinator
- 6,000 trucks per day at weigh station- need help in enforcement and safety
- Include interagency communication

ITS FOR TRANSIT

What are the Critical Issues?

- There is not enough transit
- Need rail (right of ways are not being used)
- Links between transit options
 - Rail to bus
 - Pedestrian to bus
 - Bike to bus
- Sidewalks/crosswalks/bike paths to promote pedestrians
- Inter-city connections
- Utilize multipurpose vehicles between agencies

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- Coordination of demand responsive trips between counties
- Expand growth of transit to malls
- Creation of intermodal complex (hub)
- Public education
- Implement/expand carpool/vanpool
- Develop flexible system that takes you to major attractions (Biltmore Estates, Blue Ridge Parkway)

What are the Critical Issues for Transit Providers?

- Money to expand systems
- Need to determine ridership potential

Transit Policy's Critical Issues:

- Make public transportation more attractive/accessible

What is the Ideal Transit System?

- Fair to all demographics
- Accessible
- Makes people want to take the transit
- Provide options
- Timely and reliable
- Convenience
- Multi-modal
- Need to determine locations to service and then determine how to get people there
- Needs to be a redundant system (back-ups if a system fails)

What is the Role of Technology?

- Information/communication
- Kiosks
- Information on the web
 - Chambers of Commerce
 - Tourist sites
- Networking/sharing information between schedulers (web or access based), trip board
- Tracking system (real time)
- Automated counters/data collection scanners
- Collaboration between counties to share information
- Promote competition to improve services

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TRAVELER INFORMATION SYSTEMS

Current Use:

- Radio (problem with reception in mountains)
- Highway Patrol
- Message Boards
 - Timely information
 - ♦ more accurate information
 - Dual duties for operators of system cause delays with information
 - Construction delays coming with I-26 (need to prepare now)
- State Welcome Centers
 - Links with other agencies
- Highway Advisory Radio (HAR)
 - McDowell County
 - ♦ personnel issues with operations
- Transit in Asheville is small and growing slowly
 - Limited public awareness
 - Some public interest
 - Airport being a key point of interest
 - All counties around the area expressed interest in some form of transit

Transportation Information Wish List:

- Trucking and grade issues
- Information on long queues
- Truck lane restrictions; information with signing
 - Inexperienced drivers in mountain terrain
 - Additional signing for truckers with grade information
 - Additional enforcement needed
- Tourist pre-planning
 - Intelligent vehicles
 - Voice and GPS features
 - Possible partnership with automakers, etc.
- Overhead signs
 - Investigate use of cellular technology
- Radio as medium for information
 - Possibility of dedicated FM station
- Internet
 - Need access to "Real time information"

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- Kiosk
 - Touch pad connection to internet
- FCC *211- cellular telephone- information
- Pager systems for travel information

COMMERCIAL VEHICLE OPERATIONS (CVO)

- Construction of I-26 (Sam's Gap) will add to problems
- Smokey Park Bridge- 1 lane interstate (need 24 hour tow truck)
- Median guard rail, need crossover access for EMS and Fire
- US 19-23 (future I-26 corridor) and I-26
 - ITS system for commercial vehicle operations- there is nothing existing
 - Hard to patrol (guardrail and traffic)
 - Involve locals in design
 - Diversion of commercial vehicle operations from I-40 onto I-26
 - Interstate coordination of CVO enforcement
- North Carolina is in the top 10 for commercial vehicle operations accidents
- Use web site to inform CVO of bottlenecks
- IMAP needed in this region
 - Haywood and Henderson County
 - All interstates
- Weather information is from the weather station and Highway Advisory Radio (HAR)
 - Need more weather information that is accurate
- State line CVO data center
 - Provide information on "hot spots", construction, weather, etc.
- TV, web and radio information for CVO
- More signage- travel information to route traffic around incidents
- Emergency Trailers
- Weight Stations, include weigh in motion, equip trucks with transponders
 - Hendersonville and Asheville
 - Would allow historically safe/compliant CVO to bypass to focus on "bad guys"-reduce stop time
- Look at mimicking Aspen system
 - Will improve CVO safety in area
 - Will provide information to DMV to focus enforcement on "hot spots"
- Need cameras/ability to detect incidents in field
- Public /private partnership to get information out
 - Get information across state lines on Interstate

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12:00-1:15 Lunch was served and Mr. Bill Smart, P.E., Division Engineer for the NCDOT, spoke about the history of transportation in the area, and the opportunities ITS holds for the future.

ACTION ITEM (S):

We would like your input on these minutes, as well as your input on the Summit in general. We will be holding more meetings across the state and would like to know your opinions of what was good, and what could be improved. You will receive mailings if additional meetings are scheduled in this area

Please direct any comments or suggestions you have for these minutes, the Summit, or additional technological solutions and barriers in this region on enclosed survey or to Kenn Fink via email at its-asheville@kimley-horn.com or by phone at (919) 677-2237.

Thank you for your input and support and your attendance.

National ITS Architecture Compliance

The Statewide ITS Architecture and Strategic ITS Deployment Plan development process are both intended to be planning tools. The Strategic ITS Deployment Plan is a planning document which draws inputs from potential ITS customers throughout the State and Region. These inputs are logged and documented, then ranked to provide a snapshot of the perceived ITS needs for the next 20 years. Based on this documentation, the benefits of each project or improvement can be identified and, in turn, added to regional Transportation Improvement Plans (TIP) and the North Carolina Statewide Transportation Improvement Plan (STIP).

The development of the Statewide ITS Architecture is intended to guide the implementation process by providing a structure around which to design. ITS elements and concepts are generically named to permit a wide variety of design options, changes in technology, or institutional changes that occur over time. The intent is to provide freedom to designers and implementers by providing a stable structure for interconnection while providing flexibility to meet the unique needs of specific users.

The National ITS Architecture is divided into three levels: logical, physical and technical. The logical architecture provides a functional view of a system that assists in organizing complex entities and relationships by identifying system functions and information flows. The logical architecture guides development and deployment through functional requirements that are independent of institutions and technology. The logical architecture does not identify how each ITS function is to be implemented.

The physical architecture is the physical representation of how a system should provide the desired functionality. The physical architecture defines the information and data flows between elements and the communication requirements needed to make the system function. The data flow definitions within the physical architecture require standards to provide functionality between systems, which is the basis of the ITS standards development process.

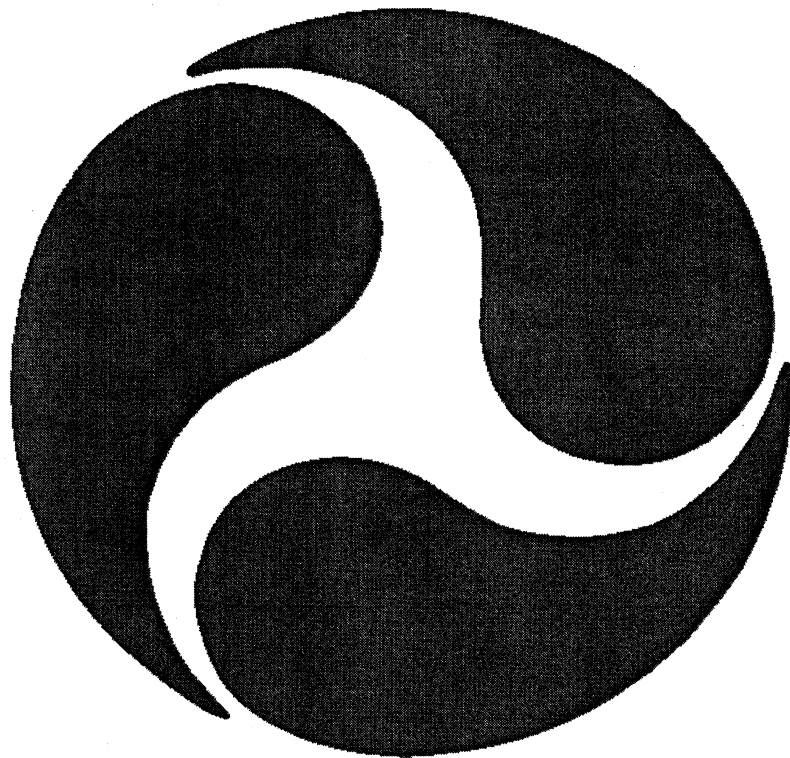
The technical architecture is the formal design and implementation process. The technical architecture defines the implementation of the physical architecture. The technical architecture is the formal design and implementation that defines system hardware and software functionality, their interaction, and the deployment of a system that processes and distributes the gathered data.

The three levels of the National ITS Architecture work together to refine the ITS needs from the planning stage down to a specific hardware deployment. For example, the logical and physical architecture may identify the need for shared traffic information. The physical architecture would define traffic information as traffic data from detectors and video from CCTV cameras.

The purpose of this document is to develop a logical architecture for ITS deployments in the State of North Carolina. The physical architecture is part of this document, but only in describing the interaction between elements, centers, etc. The appendices document the physical architecture through the data flow diagrams and other visual methods.

This document provides the logical and physical architectures as required by FHWA and used in the long-term ITS deployment throughout the state. The details in the development of the technical architecture are left up to each entity and their designers and implementers. The logical and physical architecture layers are a tool that is to be used by the designers and implementers to ensure that data and information is shared between systems. By approaching the ITS Architecture deployment from the logical and physical levels, this document will serve as a roadmap for ITS deployments throughout the State of North Carolina for years to come without locking the State into specific technologies that may change over time.

Off-Model Air Quality Analysis: A Compendium of Practice



**Federal Highway Administration
Southern Resource Center
August 1999**

Introduction

Air Quality analysis methodologies have become more refined over the years to fill the need in the transportation community to satisfy various requirements including Transportation Conformity and Congestion Mitigation and Air Quality Program project justification. Off-Model methods continue to be developed and refined to allow for analysis of innovative, as well as some common, projects to account for reductions in vehicular emissions. The most typical analysis is associated with Vehicle Miles of Travel (VMT) reductions, but reductions in emissions can also occur due to decreases in vehicular delay.

This is an observation in techniques which have been used in the South to provide for the evaluation of possible emission reductions. For the purpose of this compendium, Off-Model methodologies are analyses performed without the specific use of a Travel Demand Model. As previously stated, these analyses can be used for either of two primary purposes. These two purposes are Transportation Conformity Analyses and Congestion Mitigation and Air Quality (CMAQ) Improvement Program project justifications. The later of these two is probably the most crucial given the need for project justification as a funding mechanism; however, with the increasing difficulties in showing an offset of VMT growth in most areas, any reduction will only provide a benefit to the Conformity Process.

This compendium offers a look into several methodologies utilized in Federal Highway Administration's Southern Resource Center geographic area and may be duplicated and disseminated at will. These methodologies are not all encompassing but should offer valuable insight into Off-Model practice. Updates of this compendium will occur and include any needed changes in the reference section.

If you have any questions or comments please address them to:

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Federal Highway Administration
Southern Resource Center
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Atlanta, GA 30303-3104
(404) 562-3673

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Intersection Improvements

1. General Analysis

This analysis incorporates a conservative approach to intersection improvements. It can be used for grade separation and signal timing. The conservative approach is only analyzing Volatile Organic Compound (VOC) reductions; however, NO_x may be analyzed in a similar fashion.

The analysis is as follows:

- a) Calculate the existing VOC emissions.

$$\text{VOC}_B = \text{EF}_B * \text{VOL}_{APP} * \text{DIST}_{APP}$$

where,

VOC_B = Emissions before improvement, grams

EF_B = Emission factor (grams per mile) based on assumed speed before improvement

VOL_{APP} = Peak period approach volume

DIST_{APP} = Approach distance in miles

- b) Determine the average speed after the improvement.

- c) Calculate the VOC emissions after the improvement.

$$\text{VOC}_A = \text{EF}_A * \text{VOL}_{APP} * \text{DIST}_{APP}$$

where,

VOC_A = Emissions after improvement, grams

EF_A = Emission factor (grams per mile) based on average speed after improvement

- d) Calculate daily VOC emission reductions.

$$\text{VOC}_R = (\text{VOC}_B - \text{VOC}_A)$$

where,

VOC_R = VOC emission reductions, grams/day

2. Traffic Signal Computer Upgrade

The analysis of this project was for the upgrade of computer equipment and software, cabinets and controllers, and replacement of the Communications Plant. The justification was based on an increase in the reliability of the traffic control device synchronization in the metropolitan area. This would decrease delays and reduce vehicle idle emissions. The analysis for this project was performed as follows:

a) 3-4 minutes per vehicle per direction on a major arterial with an average vehicle rate of 38,000 vehicles or 2533 hours per day was assumed to be the savings by having the more reliable system. These are the savings for a single computer section.

b) There were 60 computer sections amounting to a savings in idle time of 152,000 hours of vehicle delay per day.

c) Emission rates were established by Hillsborough County using Mobile 5a. The rates were as follows:

CO = 0.32018 kg/vehicle hour

VOC = 0.0227 kg/vehicle hour

NO_x = 0.00988 kg/vehicle hour

d) To be conservative, especially with the negative benefits which would occur for NO_x with an increase in speed, emission benefits were assumed to occur only during the AM and PM peak periods (4 hours total).

e) The benefits were then calculated.

CO = (0.32018 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 8,111 kg/day (8.922 tons/day)

VOC = (0.0227 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 575 kg/day (0.632 tons/day)

NO_x = (0.00988 kg/vehicle hour)(152,000 veh hrs/day)(4 pk hrs/24 hrs) = 250 kg/day (0.275 tons/day)

Note: Delay reductions can be obtained through most intersection analysis software.

High Occupancy Vehicle (HOV) Lanes

1. General Analysis

Similar to the general intersection analysis, the HOV lane analysis is again conservative with only VOC reductions accounted; however, NO_x may be analyzed in a similar fashion. This analysis also assumes that emission reductions are for the HOV lane only.

The analysis is performed as follows:

- a) Calculate the existing VOC emissions.

$$\text{VOC}_B = \text{EF}_B * \text{VOL}_B * \text{DIST}$$

where,

VOC_B = Emissions before improvement, grams

EF_B = Emission factor (grams per mile) based on assumed speed before improvement

VOL_B = HOV Volume * Auto Occupancy of HOV / AO of Mixed Flow

DIST = HOV lane distance in miles

- b) Determine the average speed after the improvement.

- c) Calculate the VOC emissions after the improvement.

$$\text{VOC}_A = \text{EF}_A * \text{VOL}_A * \text{DIST}$$

where,

VOC_A = Emissions after improvement, grams

EF_A = Emission factor (grams per mile) based on average speed after improvement

VOL_A = HOV Volume after improvement

- d) Calculate daily VOC emission reductions.

$$\text{VOC}_R = (\text{VOC}_B - \text{VOC}_A)$$

where,

VOC_R = VOC emission reductions, grams/day

Transit Improvements

1. General Analysis

The key to Transit Improvements is increased ridership. If transit ridership goes up then Vehicle Miles of Travel (VMT) should be reduced proportionately. The approach to this analysis is trend, that is, the analysis should call on previous expansions and their effect on ridership as input into the analysis. Since this increased ridership actually decreases VMT, reductions are found for both VOCs and NQ.

The analysis is as follows:

a) Calculate the daily VMT reduction.

$$\text{VMT} = (\text{Avg. Daily Ridership After} - \text{Avg. Daily Ridership Before}) / \text{Avg. Auto Occupancy} * \text{Avg. Trip Length}$$

b) Calculate the reduction in daily emissions.

$$E_D = EF_x * \text{VMT}$$

where,

E_D = Daily Emissions, grams/day

EF_x = Emission factor for pollutant x, grams/mile

VMT = vehicle mile/day

2. Express Bus Service for Broward County, Florida³

The analysis of this project was done to add new Express Bus Service in Broward County Florida. The basis for the project was to provide a needed service to the general public and reduce Vehicle Miles of Travel (VMT). The new transit service will operate during the morning (AM) and afternoon (PM) peaks. The AM peak will consist of three one-way trips from southwest Broward County to Downtown Fort Lauderdale with one return trip. The PM peak will consist of the reversal of the AM peak. Each peak is considered for exactly two hours (6:00AM to 8:00AM and 4:00PM to 6:00PM). The analysis for the project is as follows:

- a) The Peak Hour Ridership was determined by running the FSUTMS model (Florida's Travel Demand Model). Both the AM and PM peak ridership were calculated by multiplying the peak hour ridership by 2.0 hours to yield Person Trips.

Peak Hour Ridership (from FSUTMS) = 54 Person Trips

AM Peak = 2.0 Hours * 54 = 108 Person Trips

PM Peak = 2.0 Hours * 54 = 108 Person Trips

Daily Person Trips = 108 + 108 = 216 Person Trips

- b) An estimate of auto trips is found by dividing the person trips by the average auto occupancy for Home Based Work (HBW) trips.

216 Person Trips / 1.12 = 193 Auto Trips

- c) An estimate of VMT is then calculated by assuming the auto trips would have taken the same trip length as the new service or 31.0 miles.

193 Auto Trips * 31.0 Miles/Trips = 5983 Daily VMT

- d) The daily reduction in NO_x and VOC is found from MOBILE 5.0a using Light Duty Gas Vehicle (LDGV) emission rates. The average speed is derived from the average auto travel speed along the proposed transit route, which is 37.9 mph.

NO_x emission reduction = $5983 \text{ VMT} * 1.63 \text{ g/mile} * \text{kg} / 1000 \text{ g} = 9.75 \text{ kg/day}$

VOC emission reduction = $5983 \text{ VMT} * 1.25 \text{ g/mile} * \text{kg} / 1000 \text{ g} = 7.48 \text{ kg/day}$

- e) The increase in VMT due to the express service is then found with the knowledge that there are four trips per peak period, again, with a distance of 31.0 miles.

Daily Transit VMT Increase = $31.0 * 8 \text{ trips/day} = 248 \text{ Daily VMT}$

- f) The daily increase in NO_x and VOC is found from MOBILE 5.0a using Heavy Duty Diesel Vehicles (HDDV) emission rates. The average speed is derived from the average bus speed along the proposed route, which is 28.7 mph.

NO_x emission increase = $248 \text{ VMT} * 1.8 \text{ g/mile} * \text{kg}/1000\text{g} = 0.45 \text{ kg/day}$

VOC emission increase = $248 \text{ VMT} * 11.68 \text{ g/mile} * \text{kg}/1000\text{g} = 2.90 \text{ kg/day}$

- g) The net reduction is then found.

NO_x emission reduction = $[9.75 - 2.90] \text{ kg/day} = 6.85 \text{ kg/day}$

VOC emission reduction = $[7.48 - 0.45] \text{ kg/day} = 7.03 \text{ kg/day}$

3. Transit Centers¹

Transit centers combine frequent bus service with park and ride (P&R) lots. The main benefit of these facilities is to reduce VMT, thus allowing for a reduction in both ozone precursors. The analysis for these facilities/projects is as follows:

a) The first step in the analysis is to estimate the number of autos removed by the new facility.

$\text{Autos Removed} = \text{Historical P\&R Lot Utilization} * \text{Parking Spaces in Lot}$

b) Next, knowing the average peak hour speed and the average driving distance for the area emission reductions can be found. Note: Distance is multiplied by 2 to account for round trip.

$\text{Auto Emission Reduction} = \text{Autos Removed} * (\text{Avg. Driving Distance} * 2) * \text{Peak Hour Speed Emission Rate for LDGVs}$

c) Calculate the emissions from the increase in transit vehicles, utilizing known Avg. Driving Distance and Avg. Peak Hour Speed.

$\text{Bus Emission Increase} = \# \text{ of Bus Increase} * (\text{Avg. Driving Distance} * 2) * \text{Peak Hour Speed Emission Rate for HDDVs}$

d) The final calculation yields emission reductions in kg/day.

$\text{Daily Emission Reductions} = (\text{Auto Reductions} - \text{Bus Increase}) * \text{kg}/1000\text{g}$

4. Park and Ride Lots¹

The P&R lot analysis is similar to the analysis of the transit center with the exception that increased bus service is not added. The analysis is as follows:

a) The first step in the analysis is to estimate the number of autos removed by the new facility.

$\text{Autos Removed} = \text{Historical P\&R Lot Utilization} * \text{Parking Spaces in Lot}$

b) Next, knowing the average peak hour speed and the average driving distance for the area the total emission reductions can be found in, kg/day.

$\text{Auto Emission Reduction} = \text{Autos Removed} * (\text{Avg. Driving Distance} * 2) * \text{Peak Hour Speed Emission Rate for LDGVs} * \text{kg/1000g}$

Note: Distance is multiplied by 2 to account for round trip.

5. Alternative Fuel Buses¹⁴

Broward County, FL proposed to buy 4 alternative fuel (electric) transit buses to operate as circulators in Downtown Ft. Lauderdale. The purpose of this analysis is to demonstrate that using electric buses instead of the heavy-duty diesel buses will improve air quality.

Assumptions

- C Buses will operate weekdays between 7:30 am and 5:30 pm (10 hours)
- C 30 minute (0.5 hour) headway between buses per route
- C Number of Daily Trips = Operation/Headway = 10 hours/0.5 hours = 20 Trips
- C Average bus running speed is 14.4 mph
- C Electric buses were assumed to produce zero emissions
- C MOBILE model was used to obtain HDDV emission rates
- C Round Trip distance is approximately 4.8 miles.

Analysis

- a) Estimate emissions due to operating 4 diesel buses.

Emissions = Number of Buses * Round Trip Length * Number of Daily Trips * Emission Factor

VOCs = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0030 kg/mile = 1.15 kg/day

CO = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0163 kg/mile = 6.26 kg/day

NOx = 4 buses * 4.8 round trip miles * 20 trips/day * 0.0149 kg/mile = 5.72 kg/day

- b) The above values reflect the emissions that would be reduced by replacement of the diesel buses with alternatively fueled buses thus showing an improvement in air quality.

6. Tampa Historic Electric Streetcar¹⁵

The proposed historic street car, when completed, provides intermodal connections for persons who arrive at the Convention Center or one of the hotels from Tampa International Airport and who have taken a taxi to downtown. To calculate emission benefits the following methodology was used.

a) Ridership projections were obtained from annual attendance figures estimated by the City of Tampa, Ybor City, the Port Authority, the Tampa Bay Lightning, the Florida Aquarium, and the Tampa Convention Center. Ridership figures were also based on the Memphis, TN streetcar project. The Memphis project is given reference since the attractions along the system are more relative to that of the Tampa/Ybor area. Based on the Memphis project a conservative 5% ridership at each of these venues was used for calculations. To estimate the miles saved an assumption was made that half of the estimated 5% ridership would ride the streetcar the 4.5 mile round trip between Ybor City and the Garrison Seaport District and the other half would ride shorter 2 mile trips.

| | Yearly Projected Attendance | 5% Ridership Assumption |
|-----------------------------|-----------------------------|-------------------------|
| Arena (Tampa Bay Lightning) | 800,000 | 40,000 |
| Aquarium | 1,000,000 | 50,000 |
| Crosstown-Ybor | 1,320,000 | 66,000 |
| Cruise Ships | 300,000 | 15,000 |
| Hogan Burke Theater | 1,000,000 | 50,000 |
| Hotels-Convention Center | | |
| Convention Center | 112,000 | 5,600 |
| Special Events | 305,000 | 15,250 |
| Hyatt Regency | 201,000 | 10,050 |
| Local Events | | |
| Guavaween | 75,000 | 3,750 |
| St. Patricks/Jose Riley | 4,000 | 200 |
| Gasparilla | 100,000 | 5,000 |
| Special Weekend | 75,000 | 3,750 |
| | | |
| Total | | 264,600 |

b) Calculate VMT reductions.

132,300 passengers travel 2.0 miles round trip = 264,600

132,300 passengers travel 4.5 miles round trip = 595,350

Total = 859,950 miles/year = 2356 miles/day

c) Calculate emission reductions achieved from the program.

Emission Reductions = VMT * Emission Factor

VOCs = 0.0014 kg/mile * 2356 mile/day = 3.3 kg/day

CO = 0.0114 kg/mile * 2356 mile/day = 27 kg/day

NOx = 0.002 kg/mile * 2356 mile/day = 5 kg/day

7. Bus Bays on Oakland Park Boulevard¹⁶

Broward County proposed to build 5 transit bus-bays along Oakland Park Boulevard between Andrews Avenue and Inverrary Boulevard. Currently there are three transit routes that provide service and make frequent stops along that segment of Oakland Park Blvd. The purpose of this analysis is to demonstrate that building bus bays will improve air quality by estimating the reduction in time loss due to buses stopping to load and unload passengers. The concept is based on the reductive effects of local transit buses on the traffic carrying capacity of an arterial street. The concept in Chapter 12 of the 1994 Highway Capacity Manual (HCM) was used to estimate that reduction. For comparison purposes, traffic carrying capacity of Oakland Park Blvd. was evaluated under two conditions: one with bus bays and the other without.

In the first case, (with bus bays), buses stop in a lane that is not used by moving traffic (curb parking lane), thereby reducing the impeding effects to other traffic. The time loss to other vehicles due to bus stopping at a bus bay is estimated at 4 seconds per bus which counts for bus acceleration and deceleration time in the traffic stream.

In the second case, buses stop in the normal traffic lane impeding traffic flow and causing queuing of vehicles behind the stopped bus. The time loss in this case includes the dwell time to load and unload passengers and time loss for stopping and starting. The time loss for the lane in which the bus operates can be estimated using equation 12-3 of the HCM.

$TL = (g/c) * N * (D + L)$ where,

TL = time loss, in seconds per hour

g/c = intersection green time/cycle time ratio

N = number of buses that stop per hour

D = average dwell time, in seconds

L = additional time loss due to stopping, starting and queuing in seconds (6 to 8 seconds on average).

The analysis covers the impact of constructing five bus bays and to simplify the calculations, the reduction was estimated for one bus bay and then multiplied by five.

Assumptions

- C Three bus routes operate along the subject segment of roadway
- C 30 minute headway per route
- C Number of buses $(3 * 60 / 30) = 6$ buses per hour
- C Buses operate 16 hours/day average weekday
- C The average speed along Oakland Park Blvd is 24.5 mph

Calculation of Loss Time with Bus Bays

The time loss is due to buses maneuvering in and out of bus bays.

Timeloss/hour = 4 seconds/bus * 6 buses/hour = 24 sec/hr

Where,

Time lost due to bus decel and accel out of bus bay, $TL = 4$

Number of buses per hour, $N = 6$

Average $g/c = 0.4$

Capacity of through lane = 1800 pcphpg (passenger cars per hour per green)

Capacity of one lane per hour at 0.4 g/c ratio = $1,800 * 0.4 = 720$ pcphpg

Total green time available to through lanes is $0.4 * 3,600 \text{ sec/hour} = 1,440 \text{ sec/hour}$

The percent loss in lane capacity may be expressed as:

$$(24 \text{ sec/hr} / 1,440 \text{ sec/hour}) * 100 = 1.7\%$$

This results in a capacity loss in the right lane of $720 \text{ pcph} * 0.017 = 12 \text{ pcph}$

Calculation of Loss Time without Bus Bays

The average dwell time using results from a field survey is 18 seconds per stop.

with,

$g/c = 0.4$

$N = 6$ buses/hr

$D = 19 \text{ sec/bu}$

$L = 6 \text{ sec/bus}$

$TL = 0.4 * 6 * (18 + 6) = 58 \text{ sec/hour}$

The percent loss in lane capacity is; $(58/1,440) * 100 = 4.03\%$

This results in a capacity loss in the right lane of $720 \text{ pcph} * 0.0403 = 29 \text{ pcph}$

Emission Reduction Estimate

Net Capacity gain due to building Bus Bays = $29 - 12 = 17 \text{ pcph}$

The distance of the highway impacted by each bus bay is 500 feet

Net VMT gained by installing Bus Bays = $(500 \text{ ft} / 5280 \text{ ft/mile}) * (17 \text{ pcph} * 16 \text{ hours/day})$
= 26 mile/day

The average travel speed is 24.5 mph

VOCs = $26 \text{ mile/day} * 2.31 \text{ g/mile} * \text{kg}/1000\text{g} * 5 \text{ locations} = 0.30 \text{ kg/day}$

CO = $26 \text{ mile/day} * 20.31 \text{ g/mile} * \text{kg}/1000\text{g} * 5 \text{ locations} = 2.64 \text{ kg/day}$

NOx = $26 \text{ mile/day} * 2.48 \text{ g/mile} * \text{kg}/1000\text{g} * 5 \text{ locations} = 0.32 \text{ kg/day}$

Vanpool Programs

1. General Analysis

Vanpools achieve emission benefits by reducing vehicle trips. Average commute distance is doubled to simulate a round trip. Average ridership should be based on historical vanpool size data obtained from the Metropolitan Planning Organization (MPO). The analysis is performed as follows:

a) Calculate vehicles removed by the vanpool.

$$\text{VMT removed} = \text{Historical Vanpool Size} / \text{Avg. Vehicle Occupancy}$$

b) Calculate the Daily Emission Reduction achieved by the reduced VMT, kg/day.

$$\text{ER} = \text{VMT removed} * \text{Avg. Commute Length} * 2 * \text{Peak Hour Speed Emission Rate (LDGV) for Pollutant} * \text{kg/1000g}$$

2. Dade County, Florida Vanpool Program⁴

The Dade County Vanpool Program provided 30 vans to qualified participants. Air quality benefits are achieved through the reduction in VMT associated with the reduction of individual commuters. The increase in vehicles due to the vans provides a somewhat negative offset of these benefits. The analysis consists of five steps.

- 1) Estimate the number of autos removed from the roadway by the vanpool program.
- 2) Calculate the Daily VMT eliminated.
- 3) Calculate the emission reductions due to the decrease in VMT.
- 4) Calculate the addition emissions generated by the new service.
- 5) Derive the Net Benefits from the Program.

The following provides an example.

- a) Reduction in Automobile use is calculated by knowing the amount of seating and the average area auto occupancy. The total seating provided by the vanpool is 345 seats, divided into vans with capacities of 15 and 8 passengers. The average auto occupancy of Dade County is 1.22 persons per automobile. The calculation is as follows:

$$\text{Autos Eliminated} = \text{Vanpool Seats} / \text{Auto Occupancy} = 345 \text{ Seats} / 1.22 \text{ Persons} / \text{Auto} = 283 \text{ Autos}$$

- b) VMT reduction is calculated through the knowledge of average round trip commuter distance for Dade County.

$$\text{VMT Reduction} = \text{Autos Eliminated} * \text{Average Commute Distance} = 283 \text{ Autos} * 21.8 \text{ Miles} / \text{Auto} = 6169 \text{ Miles}$$

- c) Emission Reductions are found by using the appropriate emission rate for LDGVs.

The Average operating speed for Dade County is 27 mph.

$$\text{Emission Reduction} = \text{Emission Rate} * \text{VMT} * \text{kg}/1000\text{g}$$

$$\text{Emission Reduction} = 81.49 \text{ kg/day CO}_2; = 10.49 \text{ kg/day VOC}; = 10.12 \text{ kg/day NO}_x$$

- d) Emission increases, due to the implementation of the new vehicles, are calculated knowing the emission rate for Light Duty Gas Trucks (LDGTs) and the VMT for the fleet. The VMT is derived from the fleet size and the average Dade commute distance, previously noted, or 654 VMT.

$$\text{Emission Reduction} = \text{Emission Rate} * \text{VMT} * \text{kg}/1000\text{g}$$

$$\text{Emission Reduction} = 10.63 \text{ kg/day CO}_2; = 1.33 \text{ kg/day VOC}; = 1.22 \text{ kg/day NO}_x$$

- e) The Net Air Quality difference is thus a product of the Reductions calculated in step c) subtracted by the Increases in emissions calculated in step d).

$$\text{CO} = 70.86 \text{ kg/day}$$

$$\text{VOC} = 9.16 \text{ kg/day}$$

$$\text{NO}_x = 8.90 \text{ kg/day}$$

Other Off-Model Methodologies

1. Incident Management⁴

The main goal of an Incident Management Program is to reduce congestion by removing vehicles which are debilitated, injured or just broke. Nonrecurring Congestion is the effect these vehicles have on the main line flow. Excess freeway emission are caused by this type of congestion. This analysis provides the basis for calculation of reduction of VOCs due to these programs; however, NO_x can be analyzed in a similar fashion.

a) Determine Regional Freeway VOC Emissions, E_B .

b) Determine Freeway Emissions due to Nonrecurring Congestion, E_C .

$$E_C = E_B * 0.049$$

Note: 4.9 Percent of Freeway Emissions are Caused by Nonrecurring Congestion.⁵

c) Next the Daily VOC reductions, E_D , are calculated. These assume, since freeway emissions are directly related to VMT, that the VMT in the program area is used to calculate emission reductions.

$$E_D = L * \text{VOL}_i * E_C / \text{VOL}_T * \text{EFF}$$

where,

L = Length of Freeway

VOL_i = Volume of Freeway i

VOL_T = Regional Freeway VMT

EFF = Project Effectiveness, 50% for Incident Detection and Response, 25% for Motorist Assistance, and 15% for Surveillance.

2. Pedestrian / Bikeway - General¹

The main goal of bicycle and pedestrian facilities is to provide other transportation options for a community. The air quality benefits, as with most projects, come with a reduction in VMT. The general calculation for these projects is shown below.

a) First, calculate the Daily VMT reduction.

$$\text{VMT Reduction} = \text{PD} * \text{Area} * \text{L} * \text{BMS}$$

where,

PD = Population density of location, persons/mile²

Area = Project length * 1 mile radius, mile²

L = Round trip length, one-half of the project length times 2 daily trips, miles

BMS = Bike mode share, %

b) Last, calculate the Daily Emission reductions for a pollutant.

$$E_D = EF_x * \text{VMT Reduction}$$

where,

E_D = Daily Emissions, grams/day

EF_x = Emission factor for pollutant x, grams/mile

VMT = vehicle mile/day

3. Bikeways - General

Little data is available on the utilization of bikeways; however, if such data is available it can prove invaluable in providing mode shift data to predict VMT reduction. The following is an analysis which shows how to calculate emission reductions if a history of mode shift percentage is known.

a) First Calculate daily VMT reduction provided by mode shift in the corridor.

$$\text{VMT Reduction} = \text{AADT in the corridor} * \text{PMS}$$

where,

PMS = historical percentage of mode shift for area

b) Last, calculate the Daily Emission reductions for a pollutant.

$$E_D = EF_x * \text{VMT Reduction}$$

where,

E_D = Daily Emissions, grams/day

EF_x = Emission factor for pollutant x, grams/mile

VMT = vehicle mile/day

4. Sidewalks Near Schools in Farragut, Tennessee⁶

This project connected and extended previously constructed sidewalks along the parental responsibility zone of the Farragut schools. This analysis assumes a minimum usage increase of 10%, with a VMT reduction of 2 miles on arterials and 5 miles on local roads. There are 5,602 students in Farragut schools. It should be noted that students walking remove 4 vehicle trips. The analysis is as follows:

a) Since VMT is reduced on both arterials and local roads, there are two VMT reduction calculations.

Students with Travel Mode Change = $5602 * .10 = 560$

VMT Reduction (Arterials) = $560 \text{ Persons} * 2 \text{ Miles / Person} = 1120$

VMT Reduction (Local) = $560 \text{ Persons} * 5 \text{ Miles / Person} = 2800$

b) Knowing the Average Speed for the given roadway classification emission factors are generated for both VOC and NO_x by roadway classification.

VOC Reduction = $(1120 \text{ VMT} * .00194 \text{ kg/mile}) + (2800 \text{ VMT} * .00227 \text{ kg/mile}) = 8.6 \text{ kg/day}$

NO_x Reduction = $(1120 \text{ VMT} * .0022 \text{ kg/mile}) + (2800 \text{ VMT} * .0019 \text{ kg/mile}) = 7.8 \text{ kg/day}$

5. I/M Compliance Changes, Texas

Procedures leading to a higher compliance rate for a I/M program benefit air quality by detecting then repairing faulty emission control systems. The Texas Air Control Board was asked to supply projected compliance rates for changes to our current I/M system. Current compliance rates for each county are available from TACB. Emission benefits are calculated with the following equations:

a) The first step is to calculate the emission rates before and after a change in compliance rates, g/day.

Improved Emissions = Projected I/M compliance * AADT * 24hr Avg. Speed Emissions

Previous Emissions = Current I/M compliance * AADT * 24hr Avg. Speed Emissions

b) The final step is to calculate the Daily Emission benefit due to the increased compliance rate, kg/day.

Daily Reductions = (Improved Emissions - Previous Emissions) * kg/1000g

6. Travel Demand Management (TDM), Public Education Campaign, Pinellas County, Florida

The purpose of this project was to provide intermodal transportation information via several programs within a public education campaign to promote a shift from the use of single occupant vehicles (SOV) to alternatives such as bicycle, public transportation, and ridesharing. By educating the public to these transportation options and their cost effectiveness, a substantial number of vehicles could be eliminated from the roadway, thus reducing VMT.

a) The first step in the analysis is to combine the knowledge of Work Trips for the area with the Trip Rate. Pinellas County has an estimated employment of 377,312. Knowing the Home Based Work Trip Rate is 1.8, provided by the FSUTMS model, Daily work trips can be calculated.

$$\text{Daily Work Trips} = \text{Total Employment} * \text{Trip Rate} = 377,312 * 1.8 = 679,162 \text{ Trips}$$

b) The 1991 Tampa Bay Regional Survey conducted by Florida Department of Transportation provided Trip Length Distribution information. This survey showed the Mean Trip Length was 26.6 minutes, reflecting travel time and terminal times. Using an average area speed of 19.6 mph the Average Trip Length can be calculated.

$$\begin{aligned} \text{Average Trip Length} &= \text{Average Travel Speed} * \text{Mean Trip Length} * \text{hr} / 60\text{min} = 19.6 \text{ miles/hr} * 26.6 \text{ min} \\ &* \text{hr} / 60\text{min} = 8.68 \text{ miles} \end{aligned}$$

c) Next the VMT reduction can be found with the knowledge of the Daily Work Trips and Average Trip Length.

$$\text{Work VMT Reduced} = 679,162 * 8.68 \text{ miles} = 5,895,123$$

d) Based on a study conducted by STAPPA/ALAPCO an estimated percent reduction in work travel VMT was found to be 0.5 %.⁸ Therefore, the VMT Reduction due to the implementation of the Public Education Campaign is:

$$\text{VMT Reduction} = 5,895,123 * 0.5 = 29,476$$

e) The final step is to calculate the emission reductions using MOBILE emission factors for the known Average Speed of 19.6 mph.

$$\begin{aligned} \text{Emission Reduction} &= \text{VMT} * \text{Emission Factor (g/mile)} * \text{kg}/1000\text{g} \\ \text{VOC Reduction} &= 29,476 * 2.36 \text{ g/mile} * \text{kg}/1000\text{g} = 69.6 \text{ kg/day} \\ \text{NO}_x \text{ Reduction} &= 29,476 * 2.46 \text{ g/mile} * \text{kg}/1000\text{g} = 72.5 \text{ kg/day} \\ \text{CO Reduction} &= 29,476 * 20.38 \text{ g/mile} * \text{kg}/1000\text{g} = 600.7 \text{ kg/day} \end{aligned}$$

7. Ramp Metering⁹

Project/Policy Description

Ramp metering is a common form of urban traffic control. It aims to reduce or eliminate operational problems resulting from freeway congestion by restricting flow to the freeway mainline. With mainline demand restricted to less than the available capacity, ramp metering tends to maintain uninterrupted, non-congested flow on the freeway. By smoothing vehicle flow, ramp metering aids in utilizing the existing freeway capacity and also reduces the probability of accidents at merge locations.

The total change in vehicle emissions due to ramp metering can be broken down into 3 elements: travel changes on the mainline, travel changes on the arterial street system, and changes in operating conditions on the ramp. All three elements are affected by the changes in traffic volumes resulting from ramp metering, including increased traffic volumes on the arterial street system. Emissions on the ramp change because of the changes in the way the ramp is operating. Ramp metering results in greater vehicle idling and greater acceleration on the ramp than is experienced without ramp metering. The travel demand forecasting model accounts for emissions resulting before the implementation of ramp metering. Therefore, the change in emissions before and after ramp metering is calculated in this analysis so that the difference can be applied to the total regional emissions from the travel demand forecasting model.

Assumptions

- 1) Vehicles entering at on-ramps are not experiencing delay before the implementation of ramp metering.
- 2) Emissions associated with the change in acceleration/deceleration on the ramps are negligible compared to emissions resulting from the increases in travel speeds on the freeway mainline.
- 3) Ramps are only metered until the maximum storage capacity of the ramp is met. After that time, ramp metering is turned off.
- 4) Queuing emissions on the ramp include that emission of the vehicle traveling on the ramp at low speeds.
- 5) No consideration was given to concurrent use of HOV facilities in the ramp metering corridor.

Emissions Analysis

a) Determine the freeway limits and time period for the ramp metering. Considerations for the implementing ramp metering are discussed in the *Manual on Uniform Traffic Control Devices* and the NCHRP Report 232, *Guidelines for Selection of Ramp Control Systems*, Page 52. The Florida DOT used freeway volume after the merge point and speed to determine if ramp metering was warranted as documented in the *Southeast Florida Intelligent Corridor System Ramp Metering Analysis*.

b) Obtain volumes (HPMS adjusted), capacities, and speeds of travel demand network links for all freeways, ramps, arterial cross streets and parallel cross streets which will be affected by ramp metering.

c) Calculate total emissions before ramp metering for the time period when ramp metering will be implemented (such as the peak period):

Total Emissions = 3 (LENGTH_i x #VEHICLES_i x EMISSIONS RATE_i)

where,

$i = 1$ to n , and n is the number of links

d) Determine ramps to be metered and their associated storage capacity and metering rates. Ramp metering rates can be determined by first calculating the reduction in demand required to result in the desired mainline operating condition. After the mainline difference is calculated, the difference is distributed between the upstream ramps. The metering rate will be dependent on the required reduction, the demand at the particular on-ramp and the storage capacity of the ramp.

The recommended minimum metering rate is 300 vehicle per hour (for a one-lane ramp), and the recommended maximum is 900 vehicles per hour (for a one lane ramp).⁹

e) Calculate total ramp delay and the maximum individual waiting time due to the implementation of ramp metering. These can be calculated using basic queuing diagrams of number of vehicle accumulated over time (see example in Figure 1).

f) Estimate the diversion of vehicles to the parallel arterial. The number of vehicles diverting will be a function of trip length, queue length, ramp delay, and the availability and efficiency of alternate routes.¹

g) Adjust volume/capacity ratios for all links as needed to account for ramp metering (queuing on the ramp) and diversion.

h) Calculate new freeway, cross street arterial and parallel arterial speeds using the travel demand model volume/delay curves.

i) Calculate after metering emissions based on new link volumes, capacities and speeds. Freeway and arterial link emissions can be calculated as described in step 3.

j) For the on-ramps, calculate queuing emissions as follows:

$$\text{Total Emissions} = \text{Total Delay} \times \text{Emissions Rate}_{\text{Idling}}$$

k) Calculate the difference between before metering and after metering emissions.

l) Calculate emission differences for all peak periods which are metered.

m) Apply the total difference in emissions for all peak periods to the total emissions calculated from the travel demand model output (total emissions before metering).

Caveats

1) The congestion mitigation benefits of ramp metering are conservative since the methodology is based on average annual daily traffic and no incident delay is incorporated into the analysis. Ramp metering will reduce incidents at the freeway merge and the associated vehicle delay.

2) The emissions estimate assumes that there will be no change in demand as a result of the ramp metering. The same number of vehicle trips will be made although they may be diverted to the arterial street systems. The methodology does not take into consideration latent demand that may be generated with better operations on the freeway; in the forecast years, this will be less critical due to the fact that demand will probably greatly exceed capacity.

8. University North Commuter Center¹³

The University North Commuter Center will offer information and related services to promote greater use of a range of commuter alternatives to SOV travel, including public transit, ridesharing, bicycling, walking, telecommuting and others. Services include a staffed information center, located at the University Mall, a transportable kiosk for special events within University North, a “Virtual Commuter Center” web page, and covered bicycle storage units available to participating employment sites. The analysis is as follows:

- a) Estimate the number of users/participants, users. 400 new users.
- b) Estimate gross vehicle trip reduction (VTR) based on mode shifts. Gross one-way vehicle trips reduced = users * mode Trip Reduction Factor (TRF).

| | Users | TRF | Daily Trips | Gross Trips Reduced |
|--------------------------------|-------|-----|-------------|---------------------|
| New Carpooler | 210 | 0.5 | 2 | 210 |
| New Vanpooler | 10 | 0.9 | 2 | 18 |
| New Transit User | 100 | 1 | 2 | 200 |
| New Bicyclist | 50 | 1 | 2 | 100 |
| New Walker | 20 | 1 | 2 | 40 |
| New Telecommuter | 10 | 1 | 2 | 20 |
| New Compressed Work Week | 0 | 1 | 2 | 0 |
| New Satellite Work Center User | 0 | 0 | 2 | 0 |

Total Gross Trips Reduced = 588

- c) Fraction of users or participants using prior HOV and/or SOV access, in percent.

HOV% = 10.0

- d) Determine net VTR. Net Vehicle One-way trips reduced = Gross VTR * (1 - HOV%/100)

Net VTR = 588 * (1 - 10/100) = 529.2

- e) Determine vehicle miles of travel reduced (VMT). Average one way trip length = 11 miles/trip.

Reduced VMT = Net VTR * Average Trip Length = 529.2 * 11 = 5821.2

- f) Determine daily emissions reduced. Daily Emissions Reduced = Emission Factor * Reduced VMT

CO Reduced = 5821.2 mile/day * 0.0114 kg/mile = 66.4 kg/day

NOx Reduced = 5821.2 mile/day * 0.0020 kg/mile = 11.6 kg/day

VOC Reduced = 5821.2 mile/day * 0.0014 kg/mile = 8.1 kg/day

9. Qualitative Analysis - Intermodal Transit Links²

Project Description

The study will examine transit system connections withing the Downtown and a Historic Area that will coordinate with other transportation components such as parking and bicycle / pedestrian facilities.

Purpose

The proposed CMAQ grant will fund a study which examines opportunities to improve the efficiency of transportation services in the Downtown and a Historic area. This project will examine optimal transfer of locations for intermodal connections between all modes of transportation including an electric streetcar, future rail transit, buses, bicyclists, pedestrians, and automobiles. Parking availability and opportunities will also be analyzed.

Project Justification

Effective intermodal connections are essential to an efficient transportation system. This study will identify optimum locations for intermodal transfers to reduce vehicular congestion, idle times in buses and automobiles, and overlapping transit service. In addition this analysis will identify ways to improve service and public use for through trips and intermodal connections by improving or streamlining routes and improving and adjusting headways. The air quality benefits derived from this project are difficult to quantify. However, for the purposes of this analysis, it is assumed that efficient intermodal connections will achieve a substantial reduction in the overall mobile source emissions in the study area for several reasons.

- C Increased transit ridership attributed to better connectivity
- C Amenities for pedestrians and cyclists (information kiosks, bike racks, shelters)
- C Increased use of non-motorized travel
- C Less vehicle idle times waiting for connections
- C Reduced, shorter internal trips, less cold starts

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